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A drift-diffusion model for spin-polarized transport in a two-dimensional non-degenerate electron gas controlled by spin-orbit interaction

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Abstract

We apply the Wigner function formalism to derive drift-diffusion transport equations for spin-polarized electrons in a III-V semiconductor single quantum well. The electron spin dynamics is controlled by the spin-orbit interaction which is linear in the momentum. In the transport regime studied, the electron momentum scattering rate is appreciably faster than the spin dynamics. A set of transport equations is defined in terms of a particle density, a spin density, and the respective fluxes. The model developed allows study of the coherent dynamics of a non-equilibrium spin polarization. As an example, we consider a stationary transport regime for a heterostructure grown along the (0, 0, 1) crystallographic direction. Due to the interplay of the Rashba and Dresselhaus spin-orbit terms, the spin dynamics strongly depends on the transport direction. The model is consistent with the results of pulse-probe measurements of the spin coherence in strained semiconductor layers. It can be useful in studying properties of spin-polarized transport and modelling spintronic devices operating in the diffusive transport regime.

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